Photonic Crystals for Compact Gas Sensors

T.M. Geppert[1], D. Pergande[2], A.v. Rhein[2], S.L. Schweizer[2] and R.B. Wehrspohn[2]
[1]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany,
[2]University Paderborn, Dep. Physics, Warburgerstr. 100, 33098 Paderborn, Germany

The band structure of photonic crystals (PhCs) strongly alters the behaviour of light within such periodically structured dielectrics. Properly designed PhCs should allow the realization of a new kind of compact spectroscopic gas sensors.

Its working principle is built on utilizing the low group velocity v_g of light in flat parts of the photonic band structure. This low v_g increases the effective interaction between the light and the gas. It therefore allows to decrease the size of the interaction volume and along with it the total size of a spectroscopic gas sensor. However, the low v_g also leads to a high reflection at the interface air/PhC due to mode and group velocity mismatch. We have developed a simple design adapted to narrow band spectroscopy that allows for a transmission of more than 90% in spectral regions with low v_g. It is based on a thin, unstructured layer of the dielectric making up the PhC at the air/PhC interfaces of a two-dimensional PhC. Numerical simulations by FEM-methods incorporating gas absorption and the impedance matching layer show that a reduction of the interaction volume by a factor of 25 to 30 is possible under realistic conditions.

We realised such structures by using macroporous silicon technology. More than 400µm deep pores with a lattice constant of 4.2µm have been realised. These deep silicon structures were partially open on both sides to allow for a certain gas flow through the structures. Transmission and reflection measurements of such structures with a length of a few mm up to one cm have been tested optically using either an FT-IR spectrometer or a QCL-Laser at the target frequency of ~10µm.